Proceedings Paper:

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School of Process, Environmental &
Materials Engineering
FACULTY OF ENGINEERING

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Using the Cone Calorimeter for Toxicity Measurements of Materials by Raw Sampling

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presented by **Abdulaziz Alarifi**

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(Awarded best presented paper)

Outline

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- Introduction
  - Why do we research Fire Toxicity?
  - How would Fire Toxicity research prevent (or reduce) fire fatalities?
- Objectives
- Experimental setup & modifications
- Results & Discussion
- Conclusions & future work

Introduction – 1

- Major Drivers of fire toxicity research
  - Disasters
  - Statistics

1985 British Airtours Flight 28M, Manchester, UK

Introduction – 2

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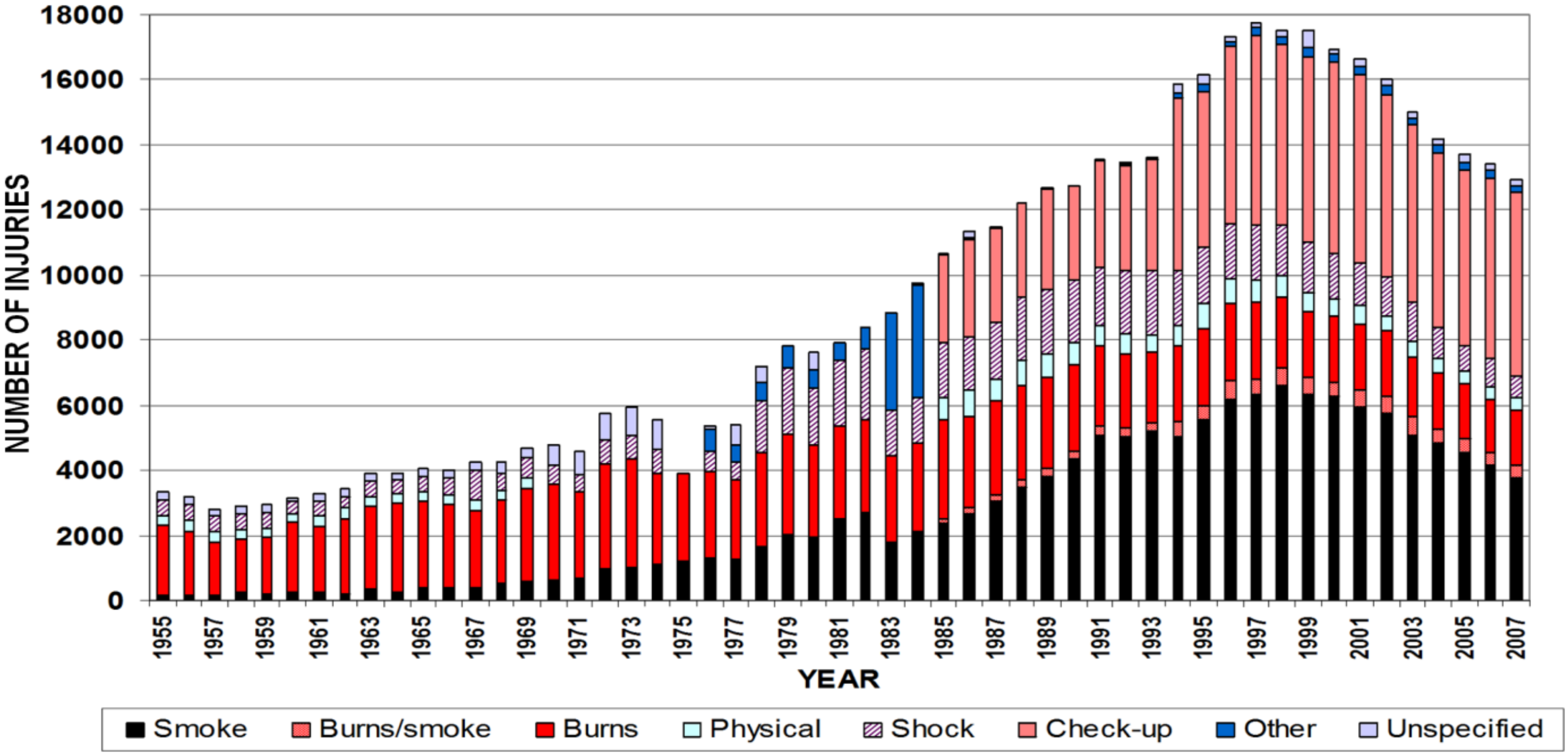
- Non-Fatal casualties in UK



Introduction – 3

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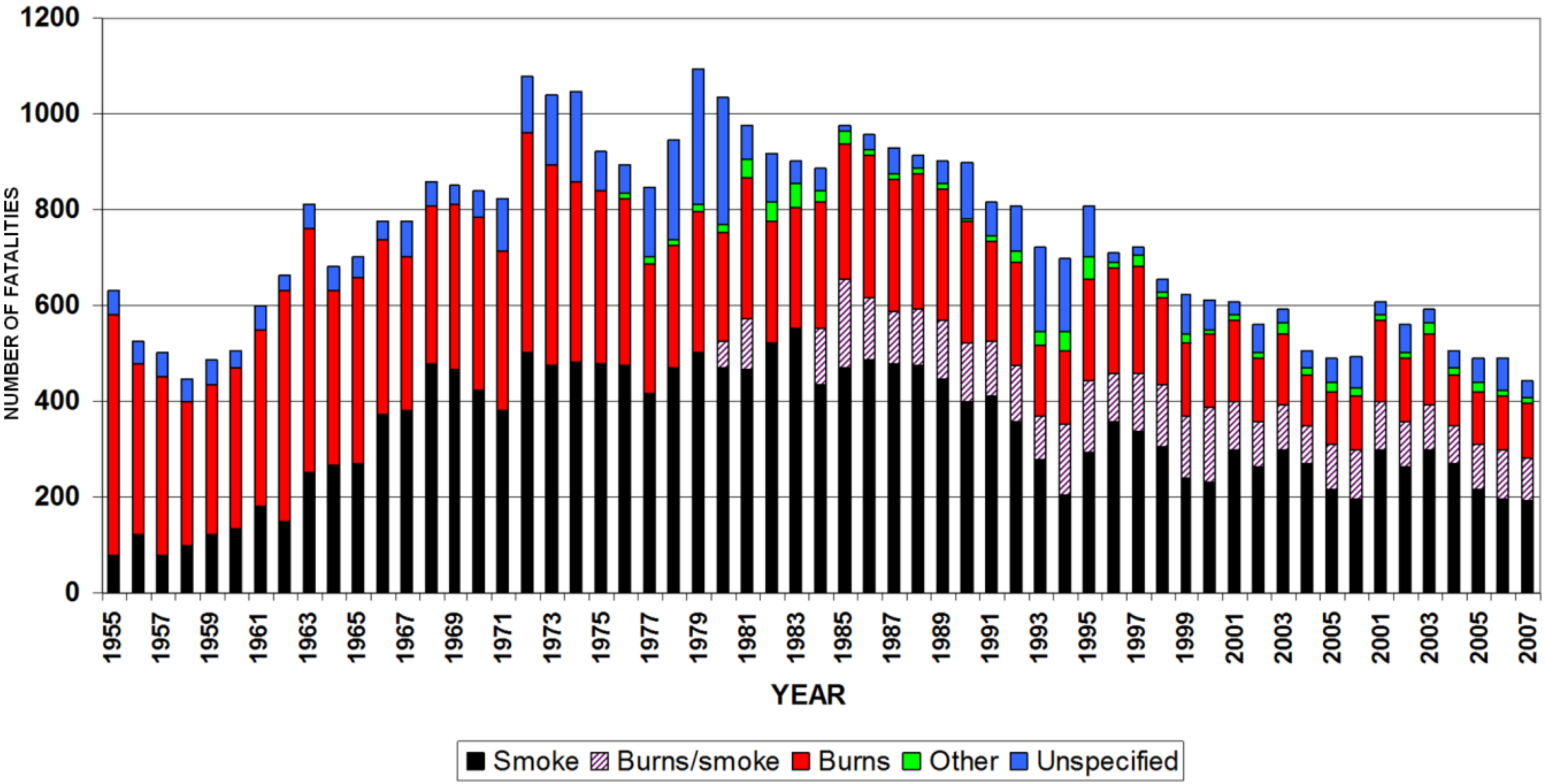
- Fatalities in UK



Introduction – 4

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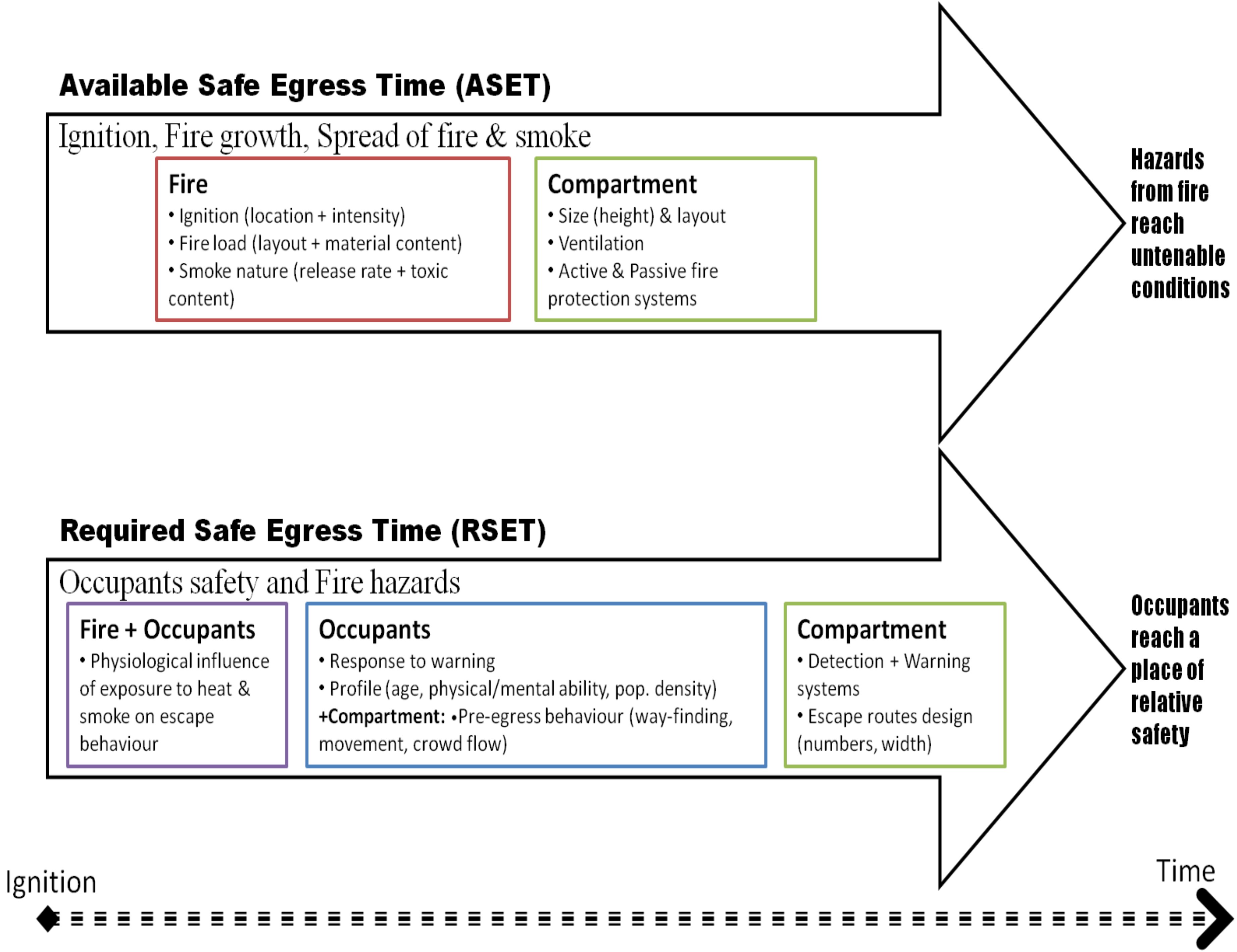
- Drivers of fire toxicity research
  - Disasters
  - Statistics
- Performance based Design

    "Performance based design in fire engineering is the application of scientific and engineering principles to the protection of people, property and the environment from fire"

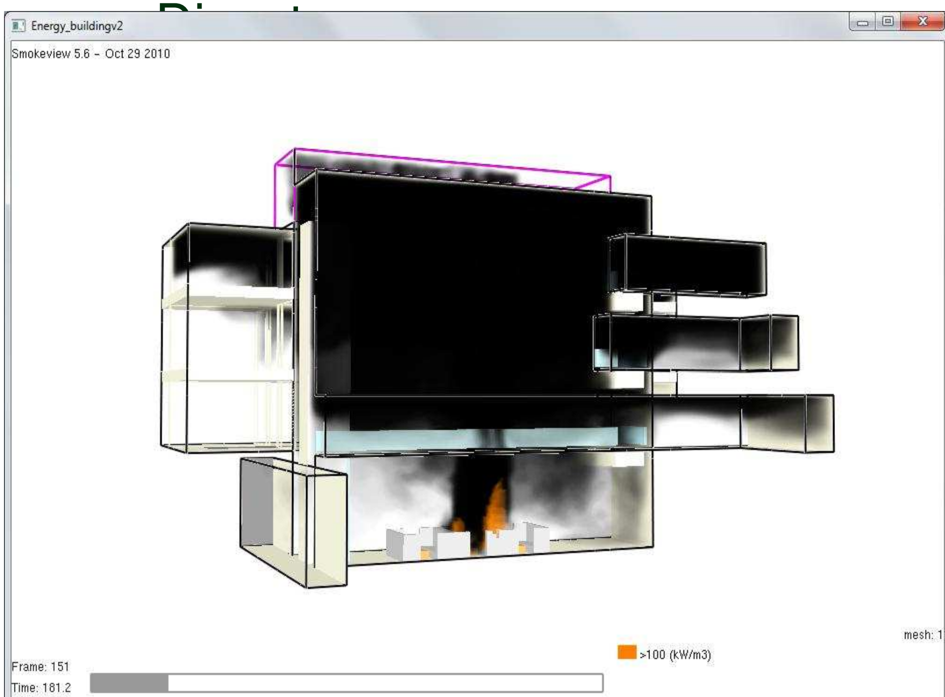
  - Practicality of performance based design
  - Available Safe Egress Time (ASET)
  - Required Safe Egress Time (RSET)

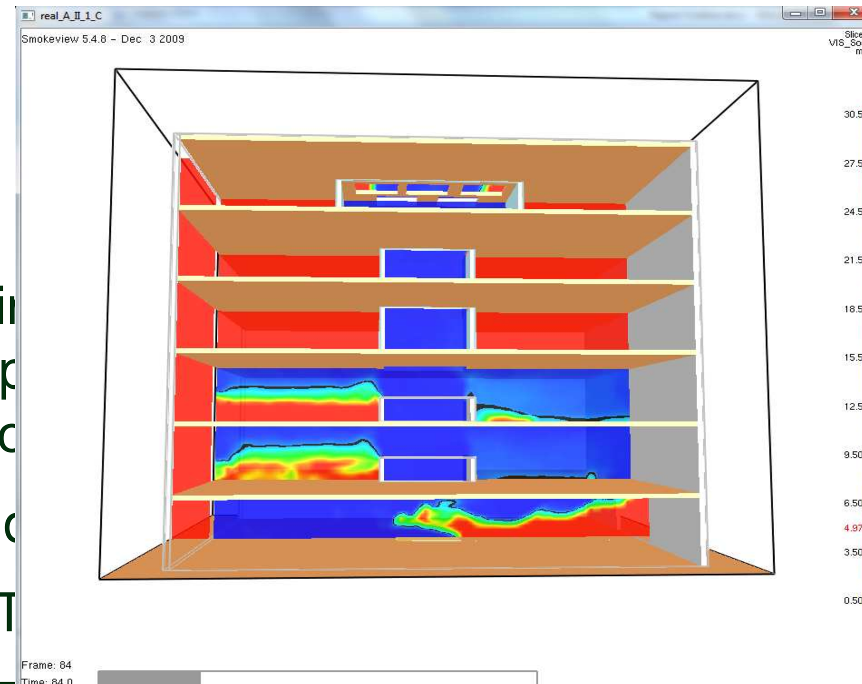


Available Safe Egress Time (ASET)
Ignition, Fire growth, Spread of fire & smoke
Fire
• Ignition (location + intensity)
• Fire load (layout + material content)
• Smoke nature (release rate + toxic content)
Compartment
• Size (height) & layout
• Ventilation
• Active & Passive fire protection systems
Hazards from fire reach untenable conditions
Required Safe Egress Time (RSET)
Occupants safety and Fire hazards
Fire + Occupants
• Physiological influence of exposure to heat & smoke on escape behaviour
Occupants
• Response to warning
• Profile (age, physical/mental ability, pop. density)
+Compartment: •Pre-egress behaviour (way-finding, movement, crowd flow)
Compartment
• Detection + Warning systems
• Escape routes design (numbers, width)
Occupants reach a place of relative safety
Ignition
Time

Introduction – 5

- Drivers of fire toxicity research





  - Required Safe Egress Time (RSET)

- CFD applications in Fire Engineering

Objectives

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- Introducing a suitable sampling system for the cone calorimeter in combination with FTIR analyser.
- Comparing measurements from both sampling points (raw and diluted) to investigate post combustion due to secondary dilution after the chimney.

Experimental setup

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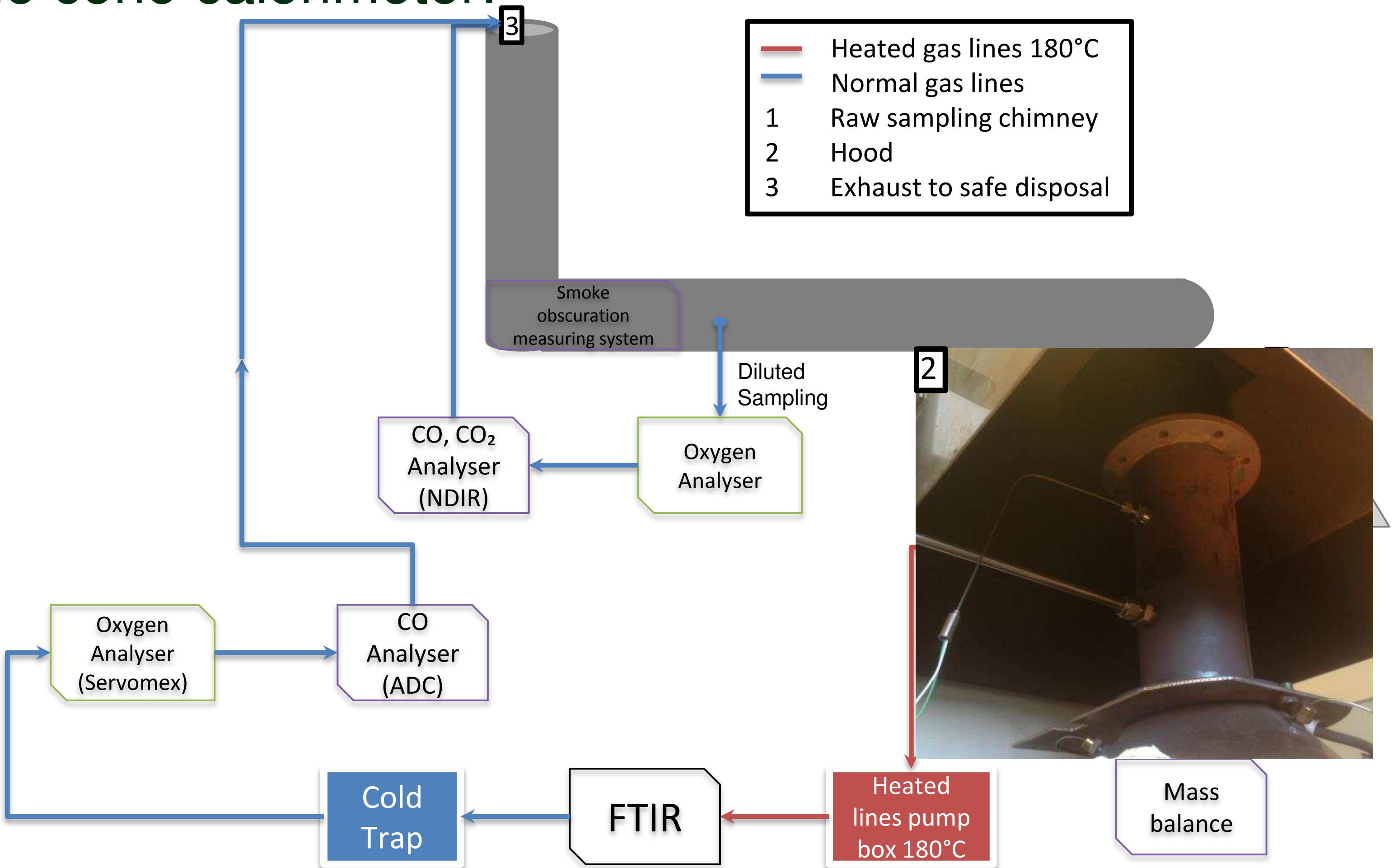
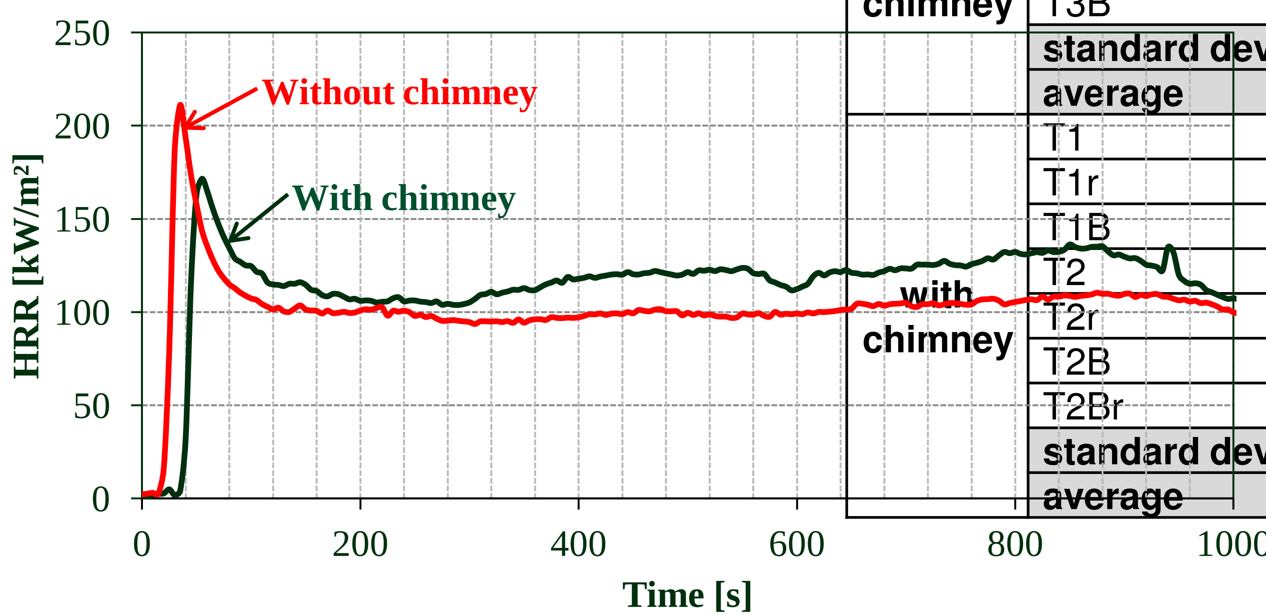
- the cone calorimeter:



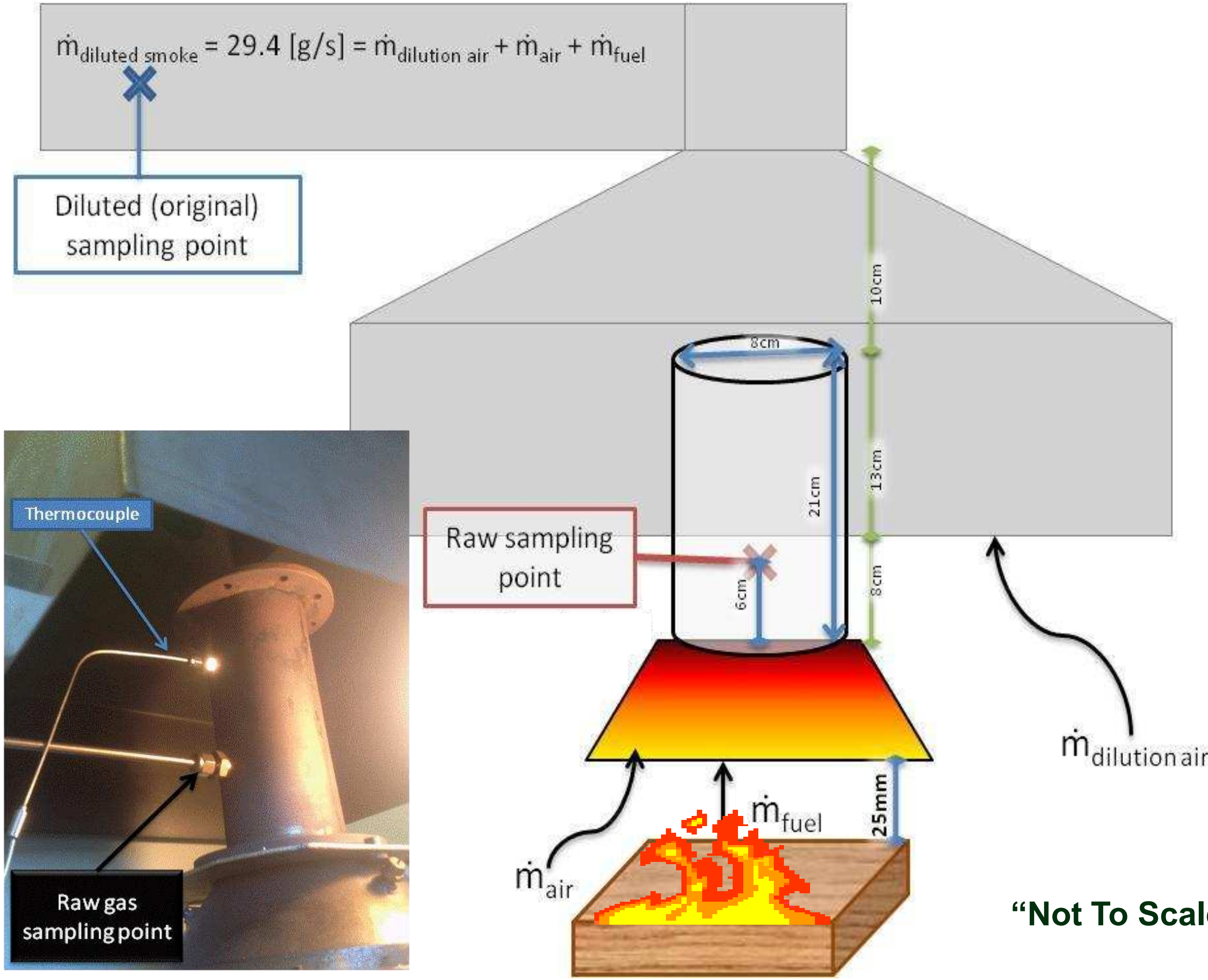
Results & discussion – 1

- Effect of Appending Chimney on the combustion process
  - Auto-ignition time
  - Heat Release Rate (HRR)

	test reference name	#	Ignition time [s]
no chimney	T3	1	26
	T3r	2	26
	T3rIII	3	22
	T3B	4	22
	standard deviation		**2.3**
	average		**24**
with chimney	T1	1	40
	T1r	2	68
	T1B	3	53
	T2	4	54
	T2r	5	46
	T2B	6	57
	T2Br	7	63
	standard deviation		**9.5**
	average		**54.4**



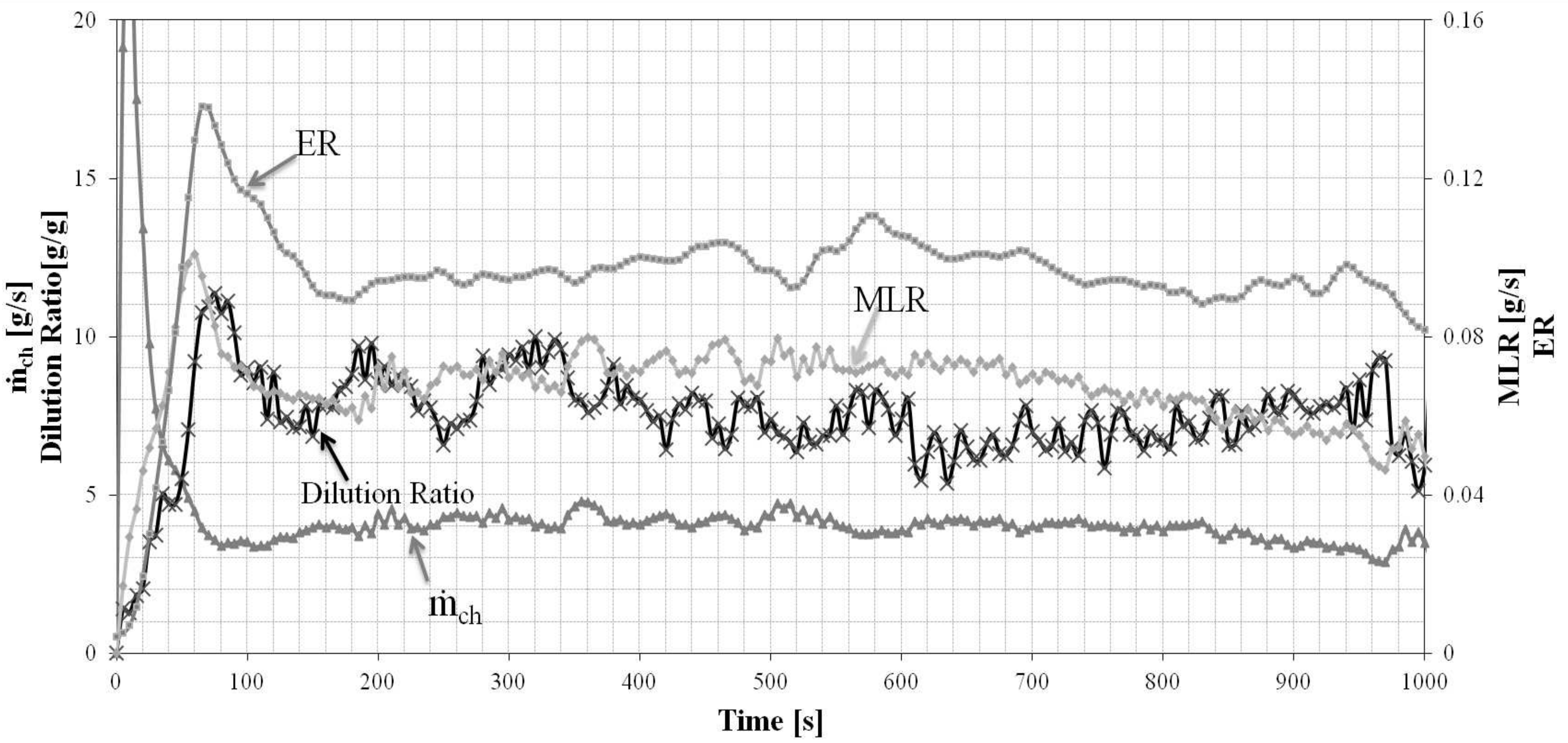
Results & discussion – 2



"Not To Scale"

Results & discussion – 3

- Dilution Ratio
  - Determination of dilution ratio



Results & discussion – 4

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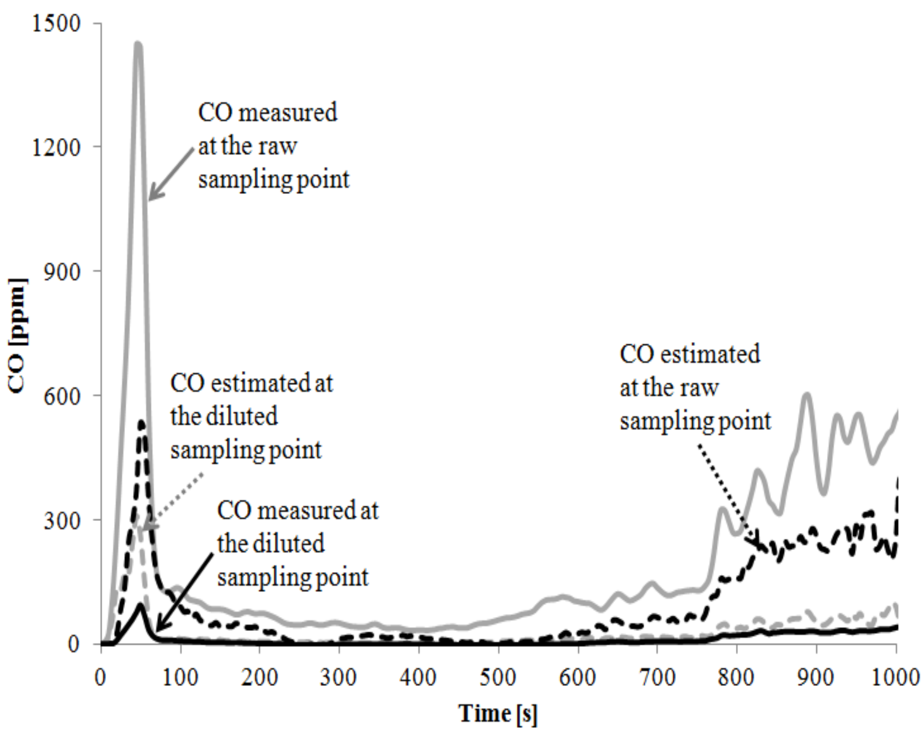
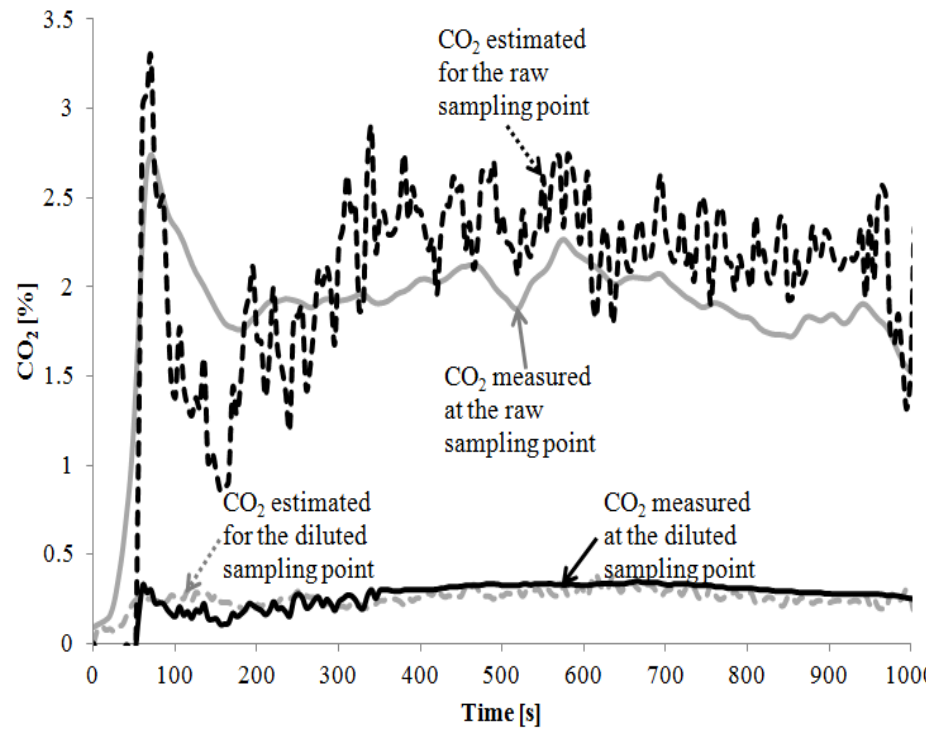
- Dilution Ratio
  - Determination of dilution ratio
  - Measured and estimated CO & CO_2 based on the dilution ratio at both





Conclusions & future work

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- Modifying the open cone calorimeter by adding the chimney can effect the combustion process due to the **chimney effect** created, **increasing air entrainments** around the **combustion zone**. However, this would **not be the case** with **restricted ventilation enclosure** as air supplied will be controlled.
- it has been shown experimentally that the **post oxidation** at the **diluted sampling point** is **present** even with freely ventilated setup.
- **Raw gas sampling** from compartment fires is the only way that the problem of **post flame oxidation** by dilution gases can be avoided and current toxic gas tests all involve post flame air dilution and hence underestimate the toxic yields.
- The cone calorimeter has been successfully modified to enable **good toxic gas yields** to be determined and should be considered as a reliable method for determining toxic gas yields in simulated compartment fire conditions with an imposed ventilation rate.

Thank you!

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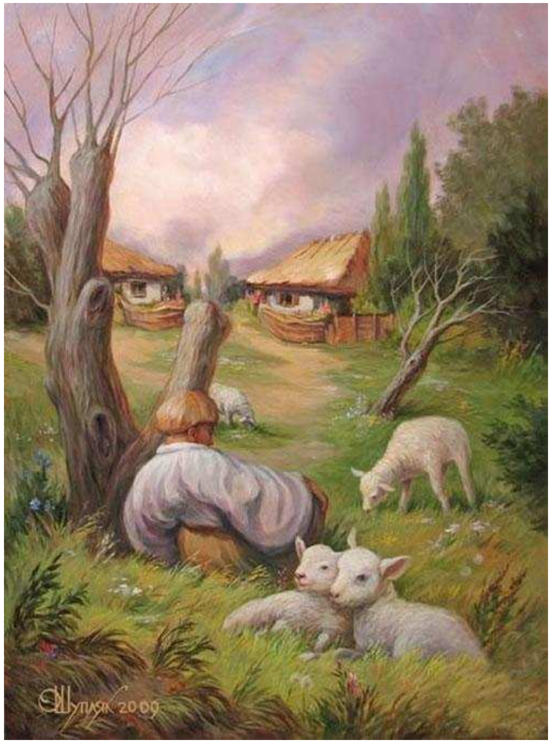

Any Questions please?